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FUEL FOR PERMISSIBLE FLAME SAFETY LAMPS

(A REVISION OF R. I. 3389)

BY

OHIO STATE

A. B. HOOKER AND E. J. COGGESHALL

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(A revision of R. I. 3389)

By A. B. Hooker[2] and E. J. Coggeshall[3]

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INTRODUCTION

Investigations at the Pittsburgh Experiment Station of the Bureau of Mines have shown that satisfactory operation of a flame safety lamp depends not only upon proper design and assembly of the lamp but also upon the kind

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7301."

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of fuel used and that much of the trouble experienced in operating permissible flame safety lamps at mines is due to the common use as fuel of motor gasolines, none of which is suitable in the present types of permissible flame safety lamps.

A report giving the results of a limited study to determine what constitutes a satisfactory fuel and suggestions as to the assembly and care of permissible flame lamps to improve their performance was published in 1938 as Report of Investigations 3389.[4] The present report is a revision to show changes in the list of recommended fuels and to meet requests for information as to the availability of the listed fuels.

ACTION OF FUEL IN LAMP

The flame safety lamps in use in the United States are of the general type shown in figure 1. The fuel is absorbed in cotton, a, in the lamp bowl or fuel fount and is taken up by capillary attraction through the wick, b, as needed.

The action of the lamp is about as follows: Fuel escapes as vapor from the exposed end of the wick, whether lighted or unlighted. When the escaping vapor is lighted, the flame immediately distills additional vapor from the wick, which burns at the outer surface of the vapor body where it is in contact with the air. The height of the flame is determined by the distance the vapor must travel in its search for oxygen before it is burned completely

If the wick is raised, the exposed wick surface and the volume of escaping vapor are increased, and the vapor body must go still higher before all of it is burned. The size of the flame is affected by other factors also, including (1) ventilation of the lamp, (2) lamp temperature, and (3) leakage of fuel vapor.

The natural ventilation of the lamp is shown by the arrows in figure 1. Most of the air enters the lamp through the lower part of the bonnet, but a small part enters through the bottom inlet ring, c, and acts to produce a stable flame. Air that enters through the bonnet goes down toward the base of the flame, thence up to the flame, giving up its oxygen in the process of combustion. The heated products of combustion rise through the center of the lamp and leave at and near the top, as shown.

As the lamp becomes warm, vaporization of fuel from the wick increases, increasing the volume and height of the flame.

Increase in size of flame and the resulting increase in temperature of the lamp interior increase the amount and velocity of the air current, which also cause the flame to elongate.

The third cause - leakage of fuel vapor - usually is due to excessive openings in the fuel fount, such as around a loosely fitting wick or an improperly assembled cover cap, d, or to pressure within the fuel fount that forces excess vapor through the wick and wick assembly.

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[4] Hooker, A. B., and Coggeshall, E. J., Fuel for Permissible Flame Safety Lamps: Bureau of Mines Rept. of Investigations 3389, 1938, 5 pp.

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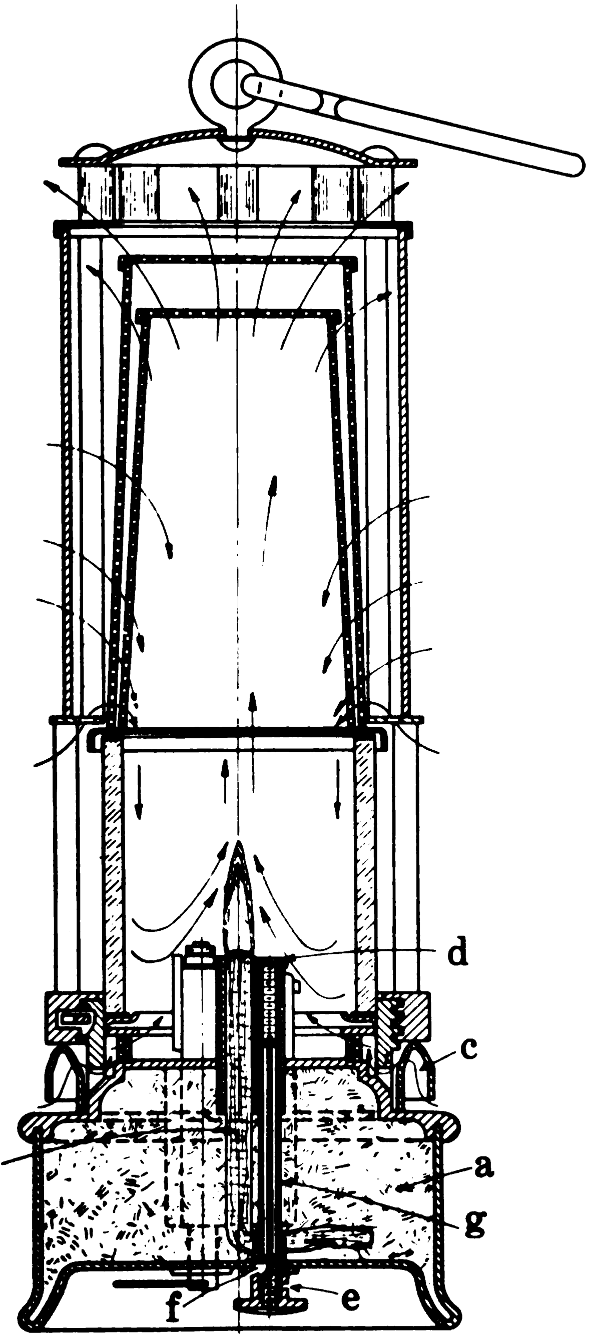

FIGURE 1.- Sectional view of flame safety lamp showing details of burning.

WHAT IS REQUIRED OF LAMP FUEL

A good flame-lamp fuel should meet the following conditions:

Minumum Gumming of Absorbent Cotton and Wick

Gum clogs both the wick and cotton, limiting the capillary action and cutting down the amount of fuel that can be put into the fuel fount per filling.

An Adequate Burning Time

Under the provisions of the Bureau's flame-lamp testing Schedule 7C lamps, to be approved, must have sufficient fuel capacity to give at least 12 hours burning per filling with approximately 1-inch flame. Low fuel capacity may be due to gumming of the cotton, as stated above, or to excessive vaporization and loss of fuel, or both.

Ease of Lighting Cold Lamp with Relighting Device

This requires a flash point sufficiently below room temperature to insure the presence of a flammable fuel vapor-air mixture at the open end of the wick.

No Corrosion of Lamp Parts

This means no, or very little, sulfur. Sulfur in the fuel corrodes the metals of the fuel fount and wick-holder assembly, producing salts that clog the cotton and complicate the action of the wick adjuster similar to the gum action.

Smokeless Flame

Flame safety lamps are used chiefly for detecting the presence of methane in mines; they are used to some extent for light and to show deficiency of oxygen, but in every use the normal flame should be well-defined and bright. A smoking flame usually is unstable; its tip is so obscured that the flame height cannot be gaged accurately, nor does it give much light. A smoking flame is due to incomplete combustion, which, in turn, is due to insufficient ventilation for the fuel used. However, with the lamp design limited by safety requirements, smoking is usually obviated by using a more suitable fuel.

FUEL-SPECIFICATION LIMITS FOR PERMISSIBLE LAMPS

The Bureau's investigation showed that the fuel for present types of permissible flame safety lamps (Koehler and Wolf) should be a highly refined, straight-run product of medium distillation range within the following specification limits:

Appearance: Shall be clear and free from suspended matter and undissolved water.

Color: A.S.T.M., shall not be darker than 25 Saybolt.

Corrosion: A.S.T.M., D130-30, a clean copper strip shall not show more than extremely slight discoloration when submerged in the fuel for 3 hours at 50° C. (122° F.).

Distillation range: A.S.T.M. D86, initial boiling point shall not be less than 90° F. Amount distilled at 155° F. shall not be less than 10 percent. Amount distilled at 210° F. shall not be less than 50 percent. Amount distilled at 290° F. shall not be less than 90 percent. End point shall not be greater than 330° F.

Gravity: A.P.I., between 60° and 70°.

Sulfur: A.S.T.M. D90-34T, maximum of 0.10 percent.

Gum: Maximum of 5 mg. per 100 ml. fuel by copper-dish test, Federal Specification Board.

Doctor test shall be very slight.

Acidity: A.S.T.M., neutral.

Such a fuel, when used in a clean and correctly assembled permissible flame safety lamp, gives a steady, well-defined flame and adequate length of burning, with no appreciable gumming of cotton and wick or corrosion of metal parts.

RECOMMENDED FUELS

Fuels with specifications within these limits are recommended by the Bureau for use in permissible flame safety lamps. The following six fuels are listed as available:

Trade name of fuel	Producer
"Atlantic 70° Naphtha"	The Atlantic Refining Co.
"Freedom Safety-Lamp Fuel"	Freedom Oil Works Co.
"Gulf Naphtha E"[5].................	Gulf Oil Corporation
"Sinclair Safety-Lamp Fuel"	Sinclair Refining Co.
"Standard Solvent Naphtha No. 1" ...	Standard Oil Co. of New Jersey
"Waverly Safety-Lamp Fuel"	Waverly Oil Works Co.

Lamps for which these fuels are suitable are often referred to as "naphtha-burning lamps" or just "naphtha lamps." "Naphtha" is an indefinite term, in that there is no general agreement as to what constitutes a naphtha However, to some refiners it means a straight-run distillate, one that has no part produced by cracking. In this respect all of the above fuels may be classed as naphthas.

Where Listed Fuel Is Available

To determine the extent to which suitable lamp fuel is available to all users of flame safety lamps, each producer, at the Bureau's request, submitted the following information concerning his listed fuel, as of January 1, 194

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[5] This fuel supersedes Gulf, clear 70 octane aviation gasoline formerly listed as "Gulf Safety-Lamp Fuel."

1. "Atlantic 70° Naphtha" Available to mining districts throughout Pennsylvania and West Virginia from bulk stations at Philadelphia and Pittsburgh, Pa.

2. Freedom Safety Lamp Fuel" Available for delivery to mining trade in western Pennsylvania, eastern Ohio, and northern West Virginia from warehouses in Freedom, Greensburg, Johnstown, Pittsburgh, Springdale, and Uniontown, Pa.; Ashtabula, Canton, Salem, Salineville, Warren, and Steubenville, Ohio; Fairmont and Wheeling, W. Va.

3. "Gulf Naphtha E" Available in 55-gallon returnable drums at practically all Gulf warehouses in the following states: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, West Virginia, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, and Texas.

4. "Sinclair Safety-Lamp Fuel" Available on order at Marcus Hook, Pa., and at all Sinclair supply stations where demand warrants.

5. "Standard Solvent Naphtha No. 1" Available at various Esso supply stations of the Standard Oil Co. of New Jersey, serving New Jersey, Delaware, Maryland, Virginia, West Virginia, North Carolina, and South Carolina. Standard Oil Co. of Pennsylvania, serving Pennsylvania. Standard Oil Co. of Louisiana, serving Tennessee, Arkansas, and Louisiana. Standard Oil Co. of Kentucky, serving Kentucky, Mississippi, Alabama, Georgia, and Florida. Colonial Beacon Oil Co., serving New York and New England States.

6. "Waverly Safety-Lamp Fuel" Available to mines of the Pittsburgh district from the refinery or through the Mine Safety Appliances Co. of Pittsburgh.

SUGGESTIONS ON ASSEMBLY AND CARE OF LAMPS THAT IMPROVE FUEL PERFORMANCE

Because of differences in the assembly and condition of lamps, a fuel performs quite differently with different lamps. Therefore, to insure good performance, even with a listed fuel, the following details should be observed:

Age of Fuel

Because of the tendency of the fuels to form gum with standing, especially if subjected to sunlight, the fuel should be relatively fresh; it should be purchased monthly, or in as small lots as is practicable, and not exposed unduly to sunlight.

Lamp Ventilation

The chief purpose of the lamp bonnet is safety, that is, to protect the gauzes against the direct movement of air currents; but, as most of the air for combustion enters the lamp through the gauzes, the bonnet must have adequate openings to permit the passage of needed air.

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Closing of the bonnet openings by dirt or by distortion may obstruct the air enough to make ventilation insufficient and to cause the flame to smoke despite the fuel used.

Excessive Fuel Feed

Excessive fuel vapor-feed that causes unsteady flame and shortens the burning time may be due to openings in the fuel fount, as around a loose wick, or to incorrect assembly of the wick tube-cap. It is often caused by pressure in the fuel fount which forces extra fuel through the wick.

Tests have shown the desirability of using a wick that fills its tube and has an indirect vent in the fuel fount. A satisfactory type of vent is shown in figure 1. The indirect opening from the outside is through hole e in the wick-adjustment nut, then through slot f to the top of tube g, thence downward to the fount interior. This type of vent is available for all models of permissible flame safety lamps.

Cleanliness

Accumulations of dirt on and in a lamp may affect both of the above conditions because it may close ventilation openings or, as a combustible, may add to the fuel and affect the size and steadiness of the flame. It is especially important that fuel spilled at filling be wiped off and that all excess fuel be well-drained from the bowl. In this respect it is best to fill the lamps several hours before they are to be used.

Renewal of Wick and Cotton

If fresh listed fuel is always used, the cotton may not need changing through periods of 5 to 10 years. However, if other fuel, such as a motor gasoline, is used at all, or if the regular fuel is old or has been stored improperly, it may be necessary to change the cotton more frequently. The wick fills with gum more quickly than the cotton and therefore may require replacement more often than the cotton.

The first evidence of gumming is its characteristic deposit around the wick and wick tube, followed by gradual stiffening of the wick. Gumming of the cotton usually is not noticed until the burning time is shortened appreciably; it would be apparent before this if the fuel were always measured at filling and the amount compared with what the freshly packed lamp takes.

In packing lamps the bowl should be filled with cotton uniformly and the wick trailed out through the cotton in intimate contact with its fuel supply. Each lamp manufacturer has developed special tools for servicing his lamps; repacking should not be attempted unless these tools are availabl

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